Basic Construction Materials
Prof. Radhakrishna G. Pillai
Department of Civil Engineering
Indian Institute of Technology-Madras

Lecture-10
Materials Engineering Concepts-Part 7

(Mechanical Properties (Cont'd))

(Refer Slide Time: 00:16)

Usually we talk a lot about mechanical properties while designing structural systems but there are also some non-mechanical properties which are very important. Essentially they are all associated with the five senses which we have, I mean even taste, we can include, but mostly not the taste part. When you talk about construction, touch, because you want whatever construction systems or facilities, the texture is also very important.

You do not want everything to be rough but sometimes you want rough surface. So, touch feel is very important along with sight, smell, and hear. All these are very important and we do consider these things while designing material systems. So, I am going to cover these four aspects only here today - acoustics, smell, aesthetics, and thermal comfort.

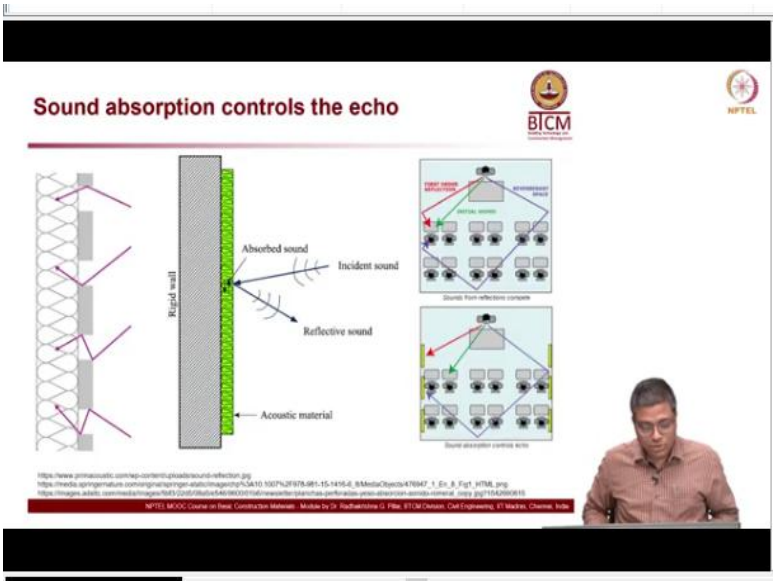
(Refer Slide Time: 01:14)

Acoustics, it is associated with the ears. If somebody's speaking in a room where you are sitting, you need to be able to hear the sound very clearly, you do not want echo. So, these are some of the things which you might be seeing in many places where you visit. You will see a lot of this perforated or these wall elements or these are the roof elements or if you are in an auditorium, you will see some cloth or cloth material on the wall.

These are all sound absorbing materials. If you replace, let us say you are in an auditorium and you replace these cloth material with like steel plates or metal plates, you will not be able to hear the program very clearly, because there will be lot of echo. So, these are very important aspects of design and materials have to be chosen in appropriately.

So, what they do or what is the working principle here? You can see on the left side here, there are four arrows which indicates how the sound waves penetrate into the sound absorbing material and then it tries to absorb the sound so that you do not really hear the echo. You can see on the left side, this is the acoustic absorbent or the noise absorbing material and these are the sound waves. It goes in and it does not come out. That is the whole idea.

(Refer Slide Time: 02:47)



You can see here the incident sound and some of the sound is absorbed by the green material which is on the rigid wall and some sound is reflected- not all. If you have fully 100 % sound waves are absorbed then you cannot hear anything that is another extreme part of it. So, you have to be able to design it appropriately, so that you can hear the sound, at the same time you do not feel the echo.

Here you can see on the right side, I just got these nice images from the internet to nicely explain the concepts. So, you can see here, the person - let us say you are in a classroom, teacher is speaking and in this case one, first order reflection, the person is getting disturbed there and you might see a lot of echo.

But in the second case, you see these three yellow sound absorbing material or board on the wall, in that case there is actually no echoing. Only this red arrow, it is hitting this and then it getting absorbed there and then this red line also comes and then it gets absorbed here. So, the people do not feel any or they do not hear any echo. So, that is the advantage and these are becoming more and more important in today's buildings.

I would also say something here. There are few decades ago, when we talk about structural design or building design, the skeleton of the building used to be the most cost intensive or in other words most expensive part of the building. The construction as such like the brickwork or the columns and beams, slabs etc. that used to be accounting for 90% of the cost.

But as time passed, we started adding heating, cooling systems or air conditioning systems, paint, interior design and many other features, electric fittings, and many things started introducing into our buildings or structures. Now the cost for that skeleton has reduced and if you take the overall contribution for a construction, the cost of the other things like this interior fittings, finishing work etc. That has significantly increased.

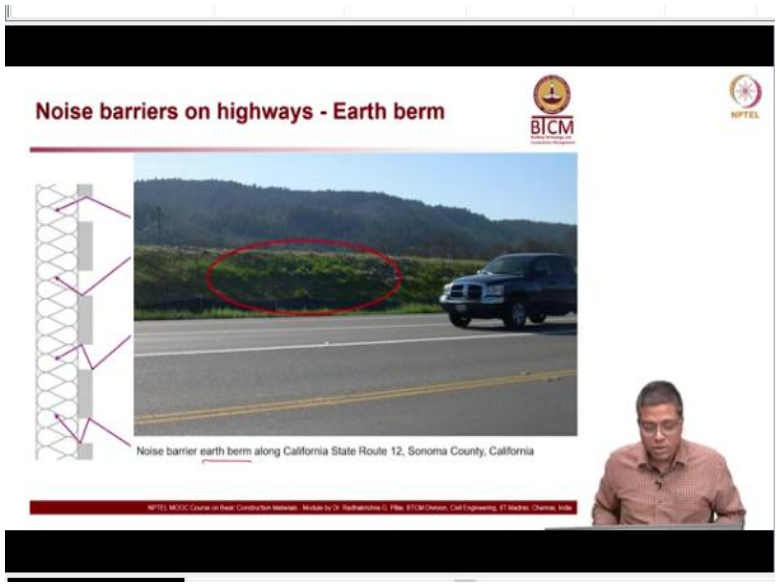
I just wanted to mention this because, these are all known structural elements which play significant role both in case of functionality of the building and in case of the cost of the building.

(Refer Slide Time: 05:52)

This is another noise barriers which you will see - I mean now in India also we see a lot of this coming up in some places. But this is widely used abroad, when you want to curb or control the noise from the vehicles. So, you can see on the picture on the right side, there are some residential areas here and that those people do not want to get disturbed by the sound or noise from the vehicle. So, they have these noise barriers.

Surface is uneven in nature. Here you can see lot of perforations, so the noise gets trapped inside and it gets absorbed by the system. So, the people on outside, they do not really get disturbed with the high heavy noise. Noise pollution is very less and it is important for both human beings and animals in the nearby areas.

(Refer Slide Time: 06:55)



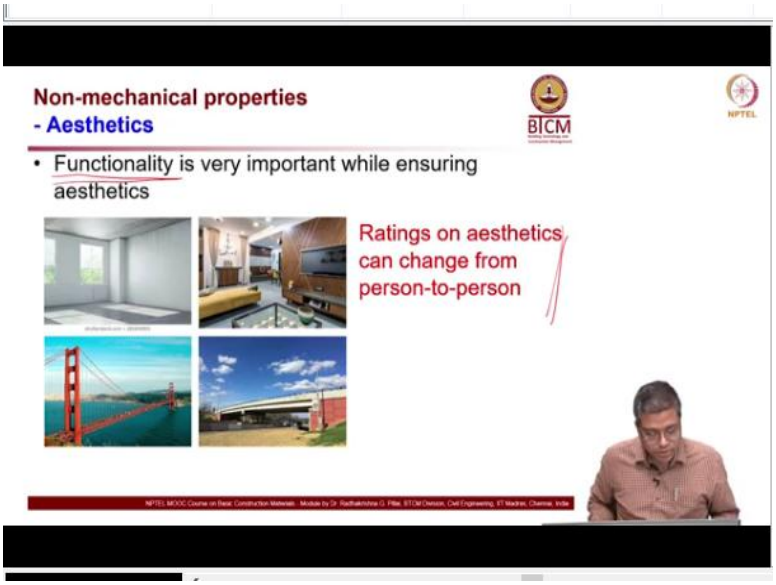
This is a probably an earlier version of noise barrier - earth berm and this is from California. So, you can see just a barrier made out of soil and of course you have small plants, grass etc. growing, that will absorb lot of noise from the vehicles.

(Refer Slide Time: 07:17)

Other thing which we have to worry about is the smell - that is our nose, the sense. The smell of wood, paint etc. sometimes creates a lot of problem. I remember many cases where people will have to keep the window open for few months before the foul smell of the paint goes away or if you use some chemicals in construction that might induce some long-term impact or it will have some influence or adverse effect on the comfort level.

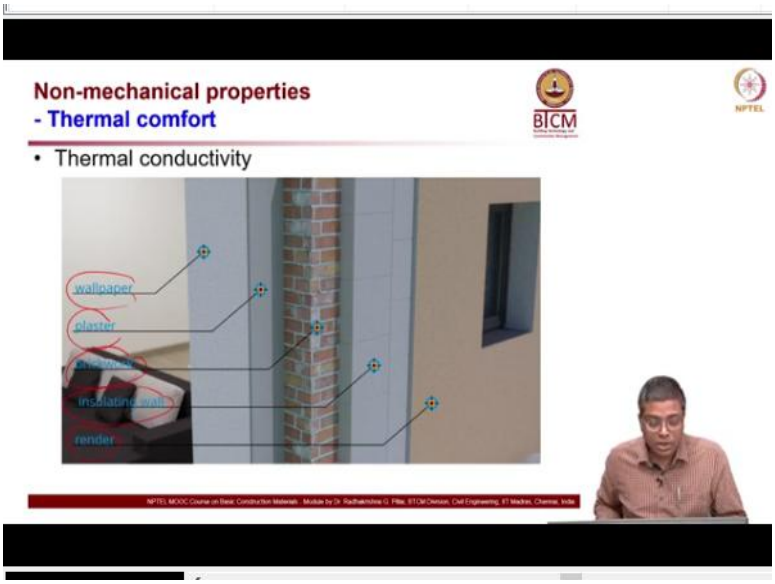
In this case, people have to keep the window open, otherwise they will not be able to work. These are all things which can go in as technical specifications, when you try to purchase paint you should ask whether it will have any bad smell and things like that. I just wanted to bring all these aspects because, sometimes we get overwhelmed with the mechanical properties alone, but there are other non-mechanical properties which play a significant role in material selection.

(Refer Slide Time: 08:31)



Other thing is aesthetics - Nothing more to talk about this, except the fact that we must remember functionality when we talk about aesthetics. Functionality is very important, aesthetic should not affect the functionality of the structure or whatever facility we are building. But this aesthetic is definitely dependent on person to person, something which I like you may not like, I might like red colour, and you might not like the red color. So, it is all person to person, architect to architect, this will change, but there are different factors which we can consider while designing the structure okay.

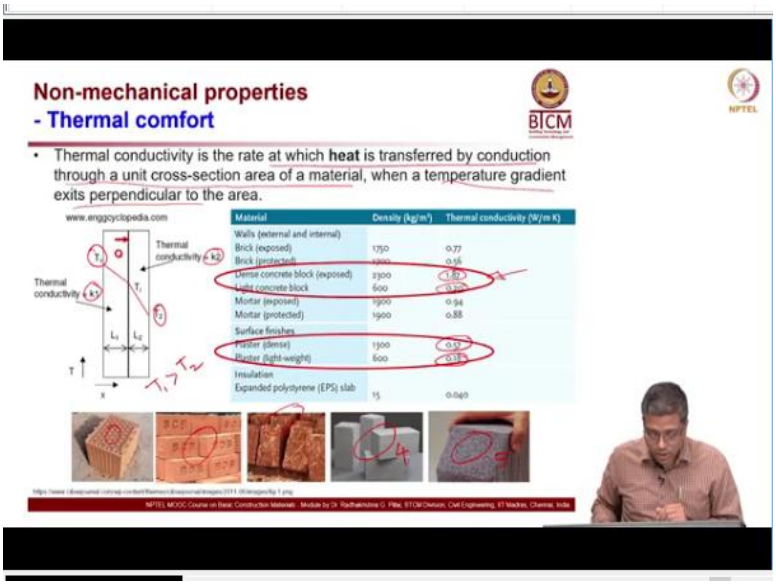
(Refer Slide Time: 09:20)



Now other parameter is thermal conductivity, again becoming more and more important in today because you are talking about climate change, lot of heat, especially in countries like India and if you are talking about other parts where in cold countries you want to contain the heat inside the building because the outside is very cold and in summer, countries where climate is very hot, there you do not want the heat to come from outside to inside the building.

So, both ways you want to prevent the exchange of heat through the wall that is the idea here. So, here is an example, photograph from the internet showing various elements - wallpaper, plaster, brickwork, insulating wall, rendering and all these can have an influence as these are different components of a wall and they all can play a role in making the house or the building thermally comfortable.

(Refer Slide Time: 10:22)



Now look at here the thermal comfort. Thermal conductivity is the rate at which the heat is transferred by conduction through a unit cross section area of the material, when a temperature gradient exists perpendicular to the area. So, here you can see on the left side there is a sketch which shows 2 materials with thermal conductivity k1 and k2, and the temperature t1 is higher than t2. So, if the conductivity is high, then you will have faster movement of the heat from one side to the other. So, you want to keep it low.

So, here are some example materials at the bottom. I am just going to take this example of brick, where you have one with a lot of open space inside. It is by design and this is a typical clay brick in second picture and the third picture is a laterite brick which also has lot of air voids inside and it is naturally available material and lot of air voids inside and people use cut in shape of the brick and then used for building construction.

Fourth one is the concrete brick and then fifth one is the aerated concrete block which also has lot of air voids inside, it is made by mixing the concrete with alumina powder and during the reaction, the hydrogen bubbles are formed and then they have lot of these well distributed air bubbles inside the brick.

That is very lightweight brick and also helps in preventing the exchange of heat from one side to the other, and also noise. So, if you have air voids inside your brick, it is good for both noise control from one room to the other and also from temperature or thermal exchange

from one side of the wall to the other side. You can look at this example of thermal conductivity for a dense concrete block is very high.

And a light concrete block is very low. That means, in the case of a light concrete block, it will take more time for the heat to get exchanged. Another example is plaster with dense is 0.57 or 0.6 and plaster light weight is 0.2 or 0.18. So, you can see that as you have light weight, meaning there may be some air in it - that is why it is lighter. So, the more air you introduce into the system, your thermal conductivity is going to be low.

When the thermal conductivity is low, it means that heat exchange is going to take more time. So, it is good to use materials which has low thermal conductivity. Now also when you talk about low thermal conductivity, another thing is advantage of all these is, typically these bricks with the porous structure or air voids inside will also have high resistance against noise.

They will also function like a noise absorbent. So, for example in the buildings, where you have a wall and if you are talking here, people in the other room need not listen to what you speak. You will see actually in today's most of the construction where they use very high quality concrete, you will see that this is a becoming a problem that somebody speaking in one room the other people in the other room can actually hear.

So, you should think about what type of material to be used for interior walls in buildings. For interior walls brick work or whatever the material we use, should have good resistance against noise, they should function like a noise barrier.

(Refer Slide Time: 14:51)

Now we talked about various things and this is the last slide in this and in design concepts, one thing which we look at is strength or mainly mechanical properties. We also look at deformation or ductility or deflection, etc. which is mainly coming from the serviceability criteria. For example, I am going to use a case of a bridge. Let us say this is a bridge here and you have a vehicle going.

Now serviceability means, this bridge should not deflect like this when the vehicle is travelling. It will deflect to some extent agreed, but it should not have so much of deflection that you start feeling worried whether you are going to fall down. So, there is a limit for deflection. So, those are again looked at through as the mechanical properties, but it has mainly the serviceability characteristics or criteria.

Then there is a third one which is durability, which is gaining more and more popularity nowadays, because we want our structures to last very long. In such case, it is more of a chemical properties and also mechanical. For example one area where you know I focus mainly is corrosion or deterioration of concrete structures where corrosion is essentially an electrochemical mechanism.

So, we look at the interaction between the steel and concrete in a particular environment, whether steel will corrode or not. So, there is essentially an electrochemical feature which we are looking at. So, I can change the chemistry of the steel and chemistry of the concrete so

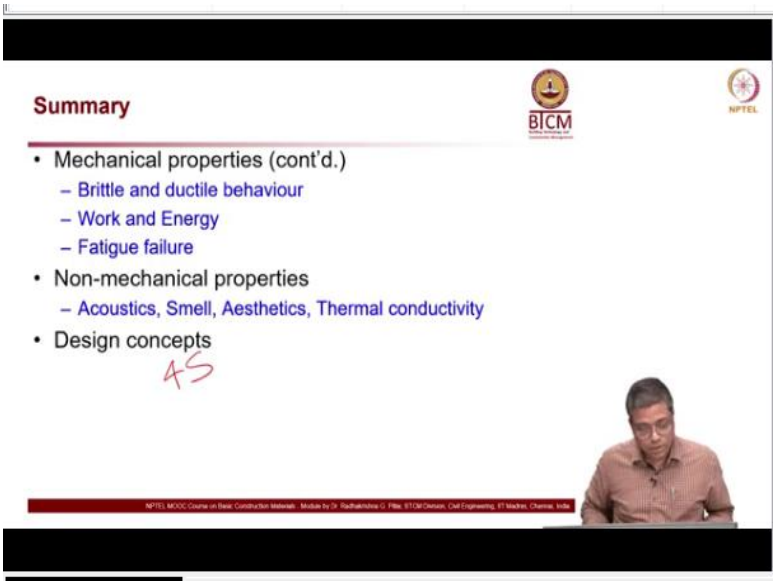
that I can have durable structure. So, it is essentially service life based design or durability based design is what we look at if you want a structure to last for 100 years.

You will see what type of concrete will give you 100 years, what type of steel will give you 100 years, like the steel concrete combination will give you 100 years of life or if you want the structure to be built only for 20 years of life, you can decide it accordingly. You do not need to then use a material which will really last for 100 years. So, these are all the concepts to know when you are designing something, you should know what is the service life required? How long you want the structure to last? And then you select your materials accordingly.

Then sustainability is again another thing, where durability is very important but also you have to look at availability of the material and what about the carbon footprint? So, many factors we have to consider when we talk about sustainability. People should like to use that thing forever, the technology should be sustainable and at the same time that material should be available for as long as possible.

So, I am going to call these as 4S for the design concepts. So, you can think about these design concepts and now do not worry only about the mechanical properties but you also have to think about other properties while designing structural systems.

(Refer Slide Time: 18:28)



Now to summarize we talked about brittle and ductile behavior, work and energy, fatigue failure, then we talked about non-mechanical properties such as acoustics, features, and smell

very briefly though, but these are important things to cover. Aesthetics, thermal conductivity and also finally looked at 4S design concepts 4S namely strength, serviceability, then service life and sustainability.